

AD612033

Final Research Report

Title: Theoretical and Field Studies of Seismic Waves

Report Period: 1 April 1962 to 1 April 1964

Project Scientist: Joseph W. Berg, Jr., 752-4211, Ext. 1539

ARPA Order No.: 292-62

Project: 8652

Project Code: 8100

Grant No.: AF-AFO R-62-376

Date of Grant: 1 April 1962

Grant Termination Date: 1 April 1964

Amount of Grant: \$88,156

Project Personnel: Joseph W. Berg, Jr., Philip R. Lein,

Giles W. Maloof, Suryya K. Sarmah,

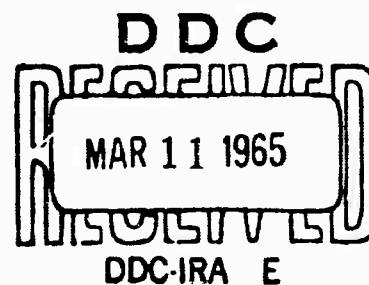
Robert H. Souders, Solon A. Stone,

William Stone, Lynn D. Trembly

COPY <u>2</u> OF <u>3</u> <u>17m</u>	
HARD COPY	\$ . 1.00
MICROFICHE	\$ . 0.50

6-p

ARCHIVE COPY



## Introduction

The objective of the research was to determine a method for evaluating the size of a seismic source using amplitudes and/or energy content of the seismic waves generated by the source. Each distance range (local, near-regional, regional, and teleseismic) was considered separately to divide the major problem into several smaller ones. During the report period only the initial seismic disturbance was considered for this work. Eventually, this work should involve other phases as well as the initial P waves that were considered. Data recorded from Gnome, Hardhat, Haymaker, and Shoa! nuclear explosions were chosen to represent the seismic sources for this work.

In the following section the research that was done for seismic waves recorded in the various distance ranges will be discussed. In general, the continuity of energy of the seismic waves recorded from the above explosions was sought for the entire range of distances over which the seismic waves were recorded.

## Approach to the Research

In essence, the analytical work involved investigating the character of primary waves generated by explosive sources. Topics that were investigated are the theoretical source function for local ranges; comparison of observed data with the theoretical source at local ranges; applying the work of Werth, Herbst, and Springer (1962) entitled "Amplitudes of Seismic Arrivals from the M Discontinuity" to seismic observations at near-regional distances; and determining a

method for normalizing primary amplitudes and energy to the source at regional and teleseismic distances. The following is a discussion of the work done for each of the distance ranges.

(a) Local Distances: A theoretical source (Blake, 1952) has been found that is believed to be consistent with observations in this range of distances. Observations from Gnome have been compared to the theoretical source, and currently three additional sets of data (Hardhat, Haymaker, and Shoal) are being compared to it. Berg and Papageorge (1964) investigated this theoretical source using the parameters obtained from the Gnome nuclear explosion. This analysis showed, among other things, that a long-period displacement field was inherent with this model, which seemed in accord with observations made by the Sandia Corporation and others. A complete description of the comparison of the theoretical source with the Gnome nuclear explosion was published by Berg, Trembly, and Laun (1964). At present data from near-regional, regional, and teleseismic distances are being reduced, propagated back to the source region, and compared with the findings listed in the paper given above.

(b) Near-Regional and Regional Distances: The method outlined by Werth, Herbst, and Springer (1962) is currently being used with the data from Gnome. The practical aspects of this method are being investigated. Mr. Philip Laun is currently working on a thesis problem which involves this work and the Gnome nuclear explosion only. Initial efforts involving extending the findings of this thesis using data from Hardhat, Haymaker, and Shoal should be completed in 1965.

(c) Teleseismic Distances: Travel times and amplitudes have been checked to determine the usability of data in this range of distances. Amplitudes of the first arrivals for the Gnome data and the data for the three additional explosions are being processed to determine the best method to normalize amplitudes and energy to determine the size of the source. Mr. Survya Sarmah is doing a thesis on the normalization of amplitudes and energies, recorded at teleseismic distances, to the near-source region.

In all of the above investigations, amplitudes, Fourier transforms of amplitudes, energy, and energy spectra are being considered. Much of the research depends upon comparing observed data with theoretical data. Thus, considerable emphasis has been placed on finding the correct theoretical model with which to compare the observations. When the analytical work for all of the four ranges has been completed, it will be tied together, the overall objective being to determine the size of the source from recordings made at all ranges.

#### Other Research Resulting in Publication

a) Berg, Gaskell, and Rinehart (1964) studied the relationships between earthquake energy release and isostasy over large portions of the earth. This work showed a definite relationship between the earthquake energy released from given areas and the average isostatic anomalies of those areas.

b) Papageorge (1964) presented a thesis to the Department of Electrical Engineering entitled "Design of an Electrical Analog for Spherical Wave Propagation in Solid Elastic Media." This thesis

investigates the design of electrical analogs to represent the propagation of seismic waves. It was partially supported by monies from this grant. Copies of this thesis have been sent to the Air Force Office of Scientific Research.

#### References

##### Bibliography of Publications Resulting from this Work:

- Berg, J. W., Jr., R. Gaskell, and V. Rinehart, Earthquake Energy Release and Isostasy, Bull. Seismol. Soc. Am., 54(2):777-784.
- Berg, J. W., Jr., G. E. Papageorge, Elastic Displacement of Primary Waves from Explosive Sources, Bull. Seismol. Soc. Am., 54(3): 947-959.
- Berg, J. W., Jr., L. D. Trembly, and P. R. Laun, Primary Ground Displacements and Seismic Energy near the Gnome Explosion, Bull. Seismol. Soc. Am., 54(4):1115-1126.
- Papageorge, G. E., Design of an Electrical Analog for Spherical Wave Propagation in Solid Elastic Media, M.S. Thesis, Oregon State University, Corvallis, Oregon, June 1964.

##### References Cited in the Report:

- Blake, F. C., Spherical Wave Propagation in Solid Media, J. Acoustical Soc. Am., 24(2):211-215, 1952.
- Werth, G. C., R. F. Herbst, and D. L. Springer, Amplitudes of Seismic Arrivals from the M Discontinuity, J. Geophys. Res., 67(4):1587-1610, 1962.

I want to thank the Air Force Office of Scientific Research and the Advanced Research Projects Agency of the Department of Defense for supporting this research.

Respectively submitted,

Joseph W. Berg, Jr.  
Professor

# Distribution List for Final Reports

Attn: SRGP Office of Scientific Research U. S. Air Force Washington, D. C. 3	Attn: Director Advanced Research Projects Agency, The Pentagon Washington 25, D. C. 6	Attn: Mr. T. W. Caless VESIAC, Institute of Science and Technology University of Michigan Ann Arbor, Michigan 2
Attn: Dr. Frank Press Seismological Laboratory California Institute of Tech. Pasadena, California 1	Attn: TD-1 Technical Applications Center Headquarters, U.S.A.F. Washington 25, D. C. 1	Attn: CRZGW A.F. Cambridge Research Lab. L. G. Hanscom Field Bedford, Massachusetts 1
Attn: Seismology Branch Coast and Geodetic Survey U.S. Department of Commerce Washington 25, D. C.	U.S. Coast and Geodetic Survey Sandia Base Albuquerque, New Mexico 1	Attn: Major Rosen, DMA Hq. Atomic Energy Commission Washington 25, D. C. 1
Attn: Blast and Shock Division Defense Atomic Support Agency Washington 25, D. C. 1	Attn: Accession Division Defense Documentation Center Arlington Hall Station Arlington 12, Virginia 20	VEIA UNIFORM c/o Code TD-1A A.F. Technical Applications Center Washington 25, D. C. 1
Attn: Crustal Studies Branch U. S. Geological Survey 7580 W. 16th Avenue Lakewood 15, Colorado 1	U.S. Arms Control and Disarmament Agency Reference Research Service Washington 25, D. C. 1	Attn: Librarian - Code 2027 Naval Research Laboratory Washington 25, D. C. 1
Attn: Code 410 Office of Naval Research Washington 25, D. C. 1	Attn: Dr. J. T. Wilson Inst. Science and Technology University of Michigan 2038 East Engineering Bldg. Ann Arbor, Michigan 1	Attn: Dr. V. Hugo Benioff Seismological Laboratory California Inst. Technology Pasadena, California 1
Attn: Dr. Sidney Kaufman Shell Development Company Post Office Box 481 Houston, Texas 77001 1	Attn: Dr. Jack Oliver Lamont Geological Observatory Columbia University Palisades, New York 1	Attn: Documents Control Inst. of Defense Analysis 1666 Connecticut Ave., N.W. Washington 9, D. C. 1
Attn: Dr. Roy Hanson Earth Sciences Division National Science Foundation Washington 25, D. C. 1	Attn: RROSE Office of Aerospace Research U. S. Air Force Washington 25, D. C. 1	Attn: Scientific Info. Branch Chief of Research and Develop. Department of the Army Washington 25, D. C. 1
Attn: Mr. Harry Matheson National Bu. of Standards Building 115 Washington 25, D. C. 1	Attn: Commander SCC A.F. Systems Command Andrews Air Force Base Washington 25, D. C. 1	Attn: Father W. V. Stauder Institute of Technology St. Louis University St. Louis, Missouri 1

Attn: Dr. J. S. Steinhart  
Dept. of Terrestrial Magnetism  
Carnegie Institution  
5241 Broad Branch Road, N.W.  
Washington 15, D. C. 1

Attn: Executive Director SRG  
A.F. Office of Scientific Res.  
Washington 25, D. C. 1

Attn: Technical Information  
Division SRIL  
AF Office of Scientific Res.  
Washington 25, D. C. 3

Attn: AFDRD  
Director Research and Development  
Headquarters, U.S.A.F.  
Washington 25, D. C. 1